A quantitative health impact assessment of urban greenspace and all-cause mortality across 1,041 global cities

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SUPPLEMENTAL MATERIAL

Contents of this file

List S1. *Countries not represented in analysis.*

1. Andorra
2. Antigua and Barbuda
3. Eswatini (former Swaziland)
4. Dominica
5. Grenada
6. Holy See
7. Kiribati
8. Liechtenstein
9. Marshall Islands
10. Micronesia (Federated States of)
11. Nauru
12. Palau
13. Saint Kitts and Nevis
14. Saint Lucia
15. Saint Vincent and the Grenadines
16. Samoa
17. San Marino
18. Seychelles
19. State of Palestine
20. Tonga
21. Tuvalu
22. Vanuatu

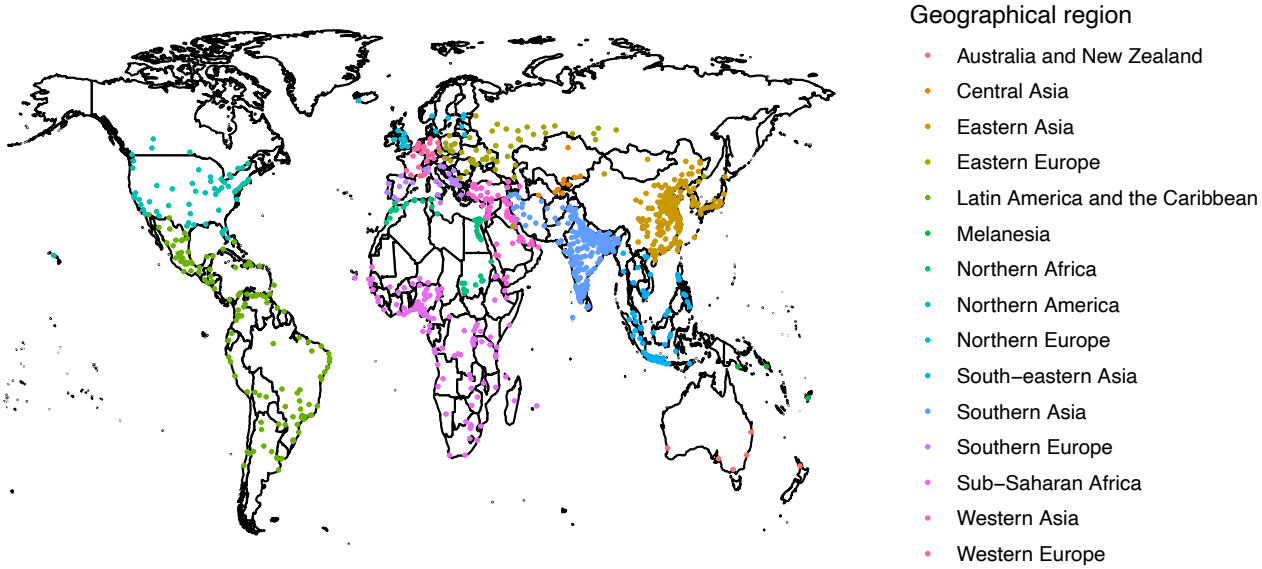

Figure S1. *Map of the 1,041 global cities by United Nations Statistical Division sub-regional classifications.*

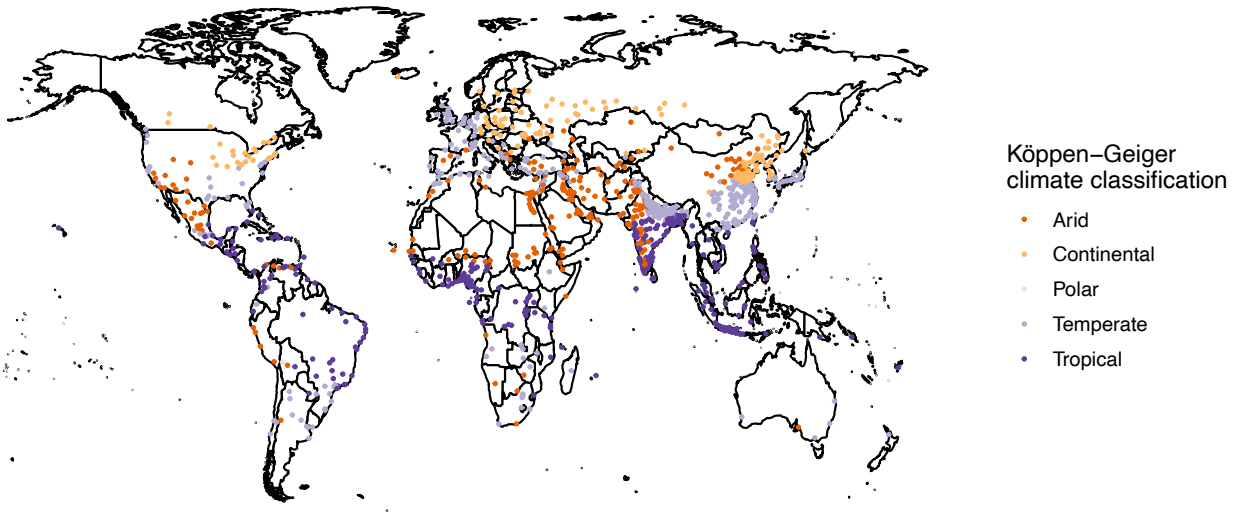

Figure S2. *Map of the 1,041 global cities by Köppen-Geiger climate classification.*

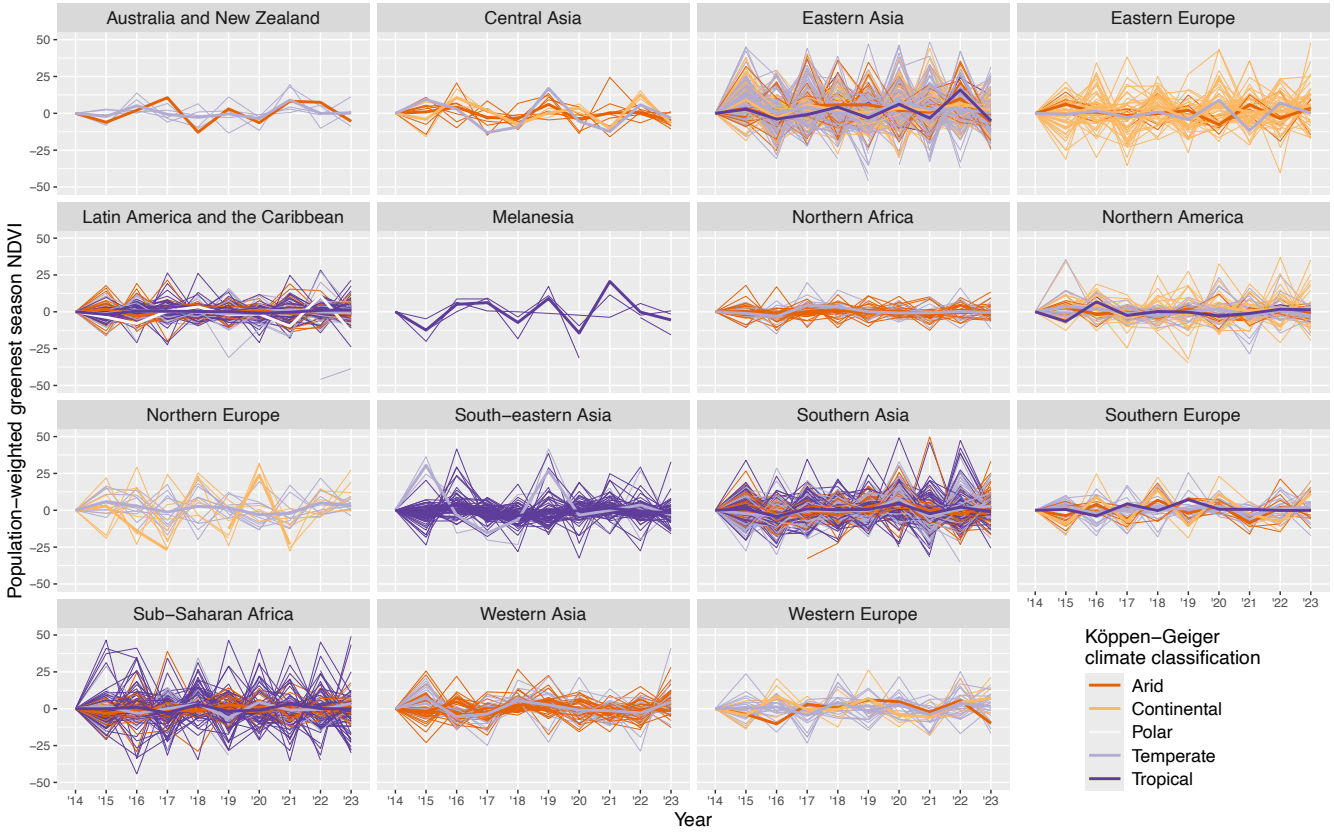

Figure S3. *Percent change from previous year in city average annual population-weighted greenest season Normalized Difference Vegetation Index (NDVI) from 2014-2023 by geographic region. Thin lines represent individual cities, and thick lines show the average NDVI percent change for all cities, colored by climate classification.*

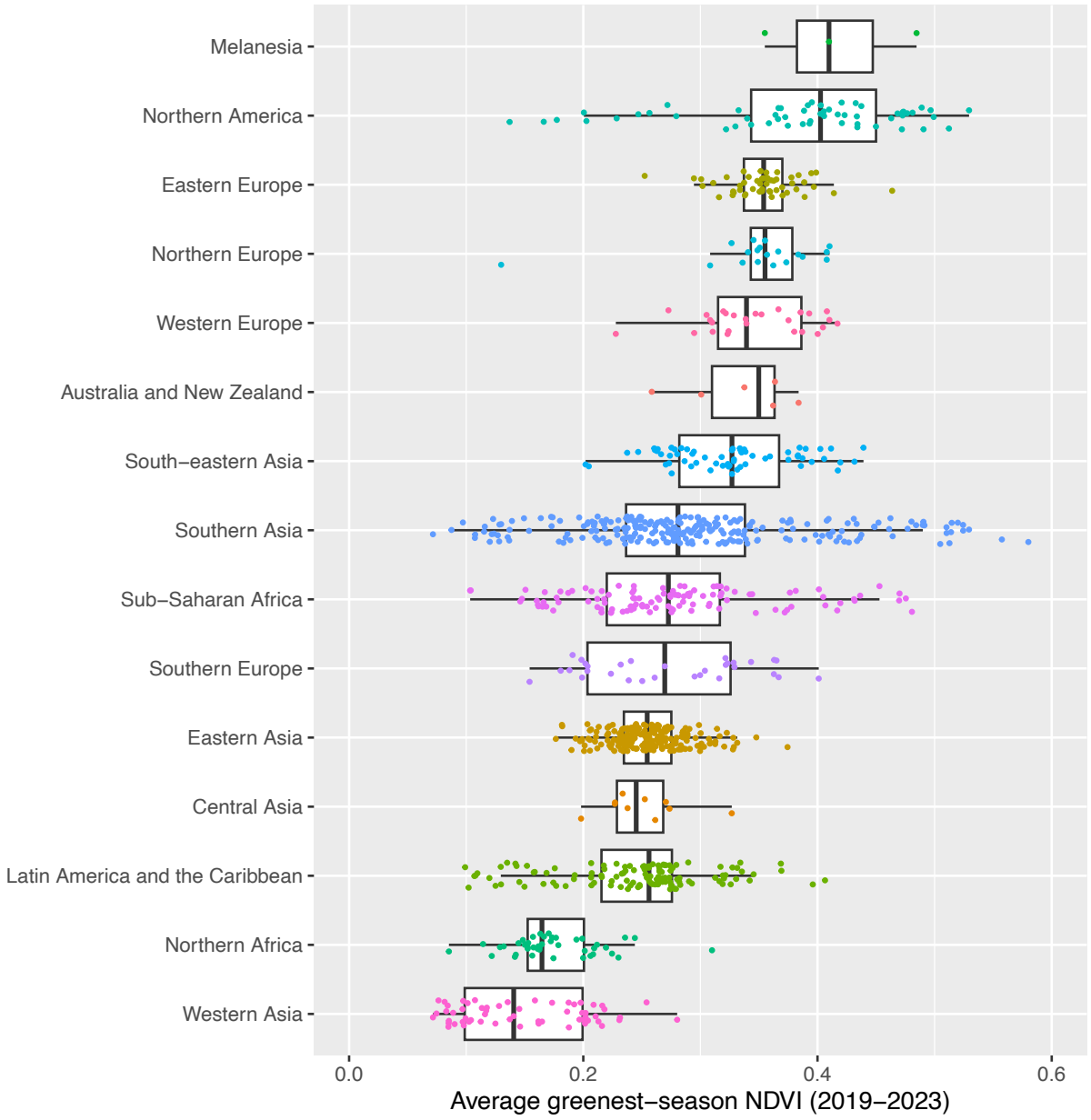

Figure S4. *Average 2019-2023 city-level population-weighted greenest season Normalized Difference Vegetation Index (NDVI), by geographic region.*

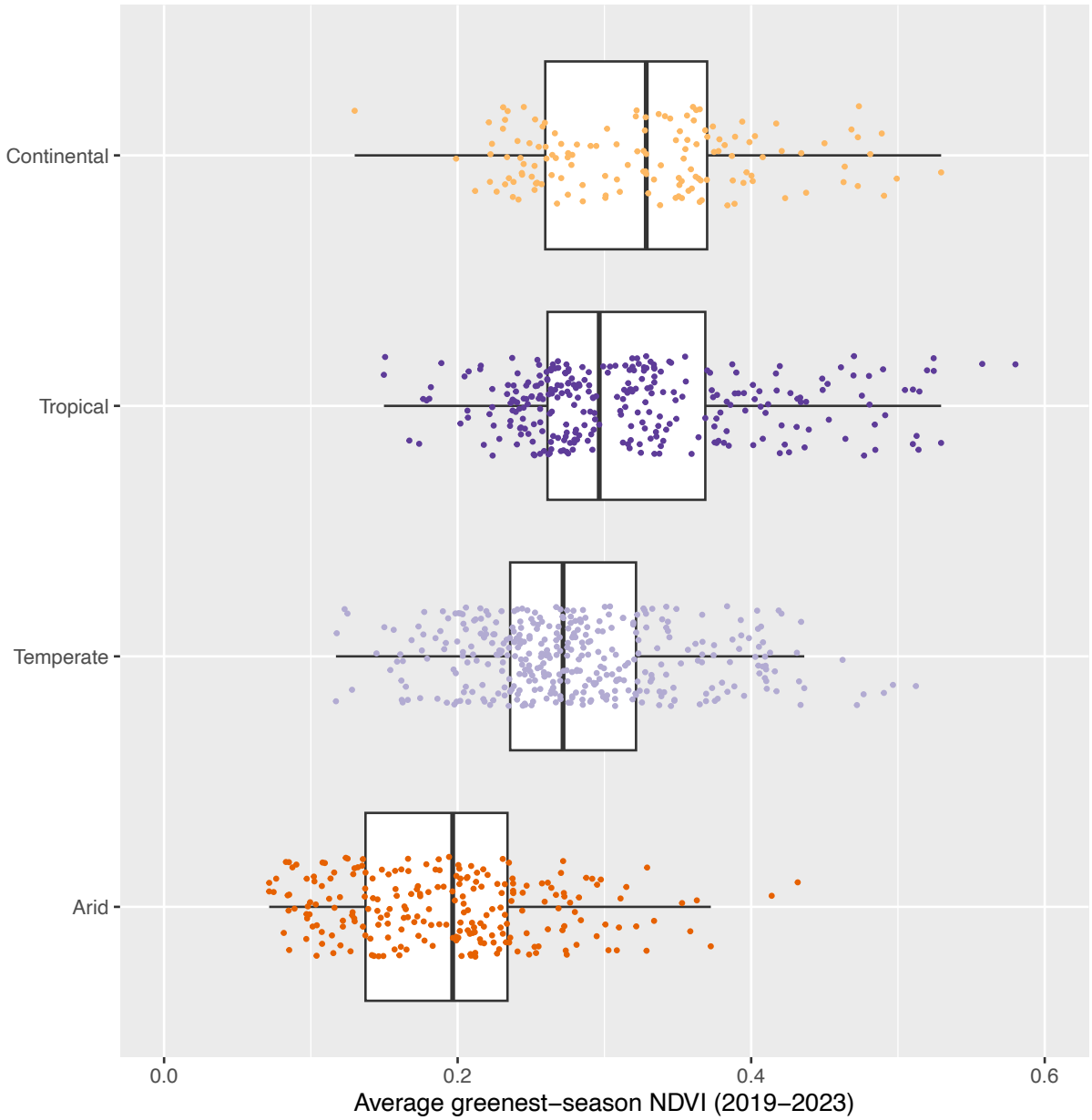

Figure S5. *Average 2019-2023 city-level population-weighted greenest season Normalized Difference Vegetation Index, by Köppen-Geiger climate classification. One city classified as Polar was dropped (El Alto, Bolivia, 0.107).*

Changes in NDVI from 2014-2018 to 2019-2023 were associated with an estimated average of 3 fewer (95% CI: 1, 6) deaths globally, and a median change of 2 more (95% CI: 1, 4) deaths. Large negative outliers including Bejing, China; Moscow, Russia; Shanghai, China; and Delhi, India are responsible for the change in signs between the mean and median values. Regional and climate patterns mirror those scaled to population. However, the absolute results have much wider distributions driven by cities with large populations.

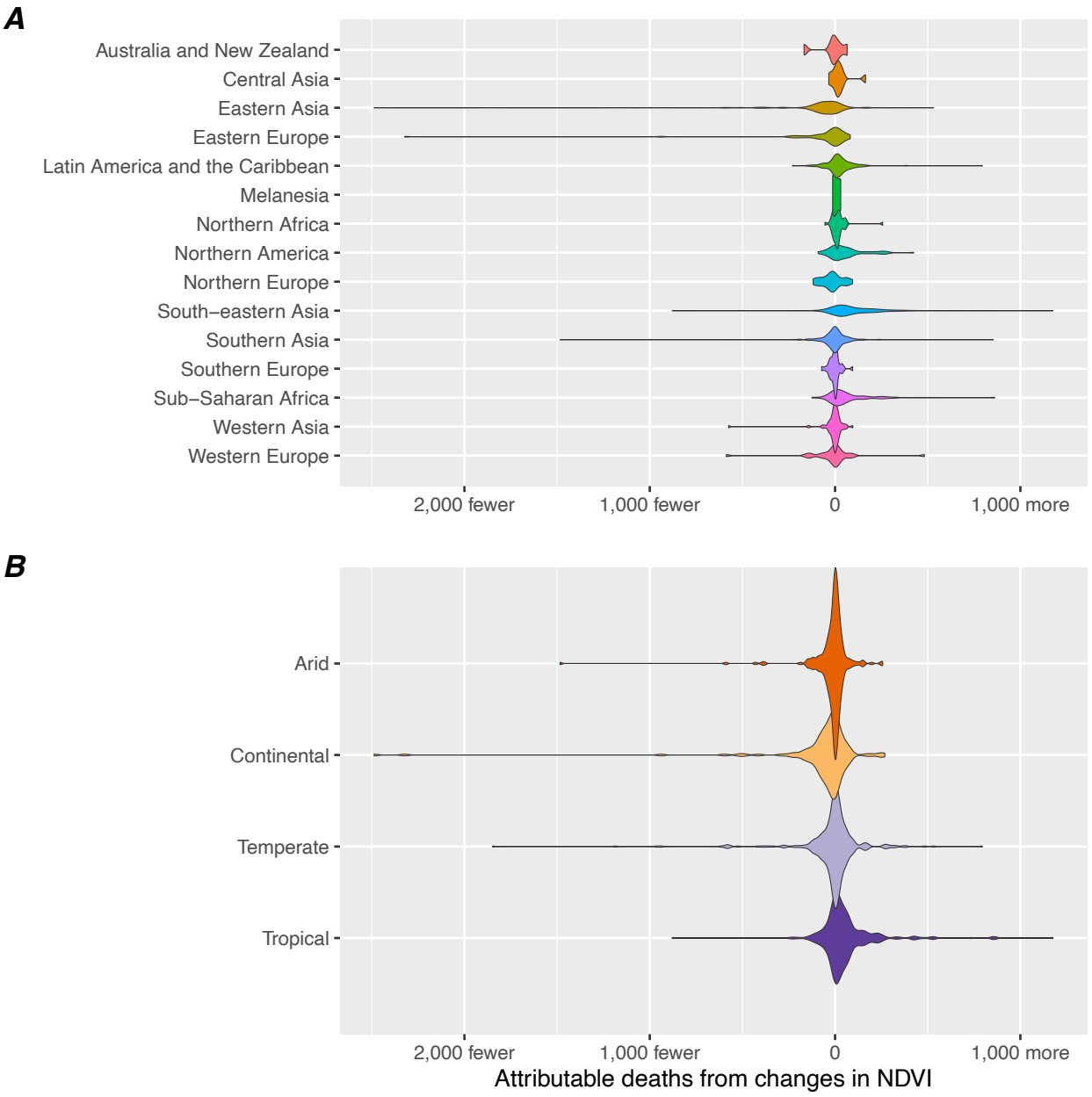

Figure S6. *Associated changes in city-level mortality from changes in average population-weighted peak season Normalized Difference Vegetation Index from 2014-2018 to 2019-2023 to the 2020 population, by geographical region (panel A) and climate classification (panel B). One city classified as "Polar" was dropped from panel B (El Alto, Bolivia, 90 more deaths).*

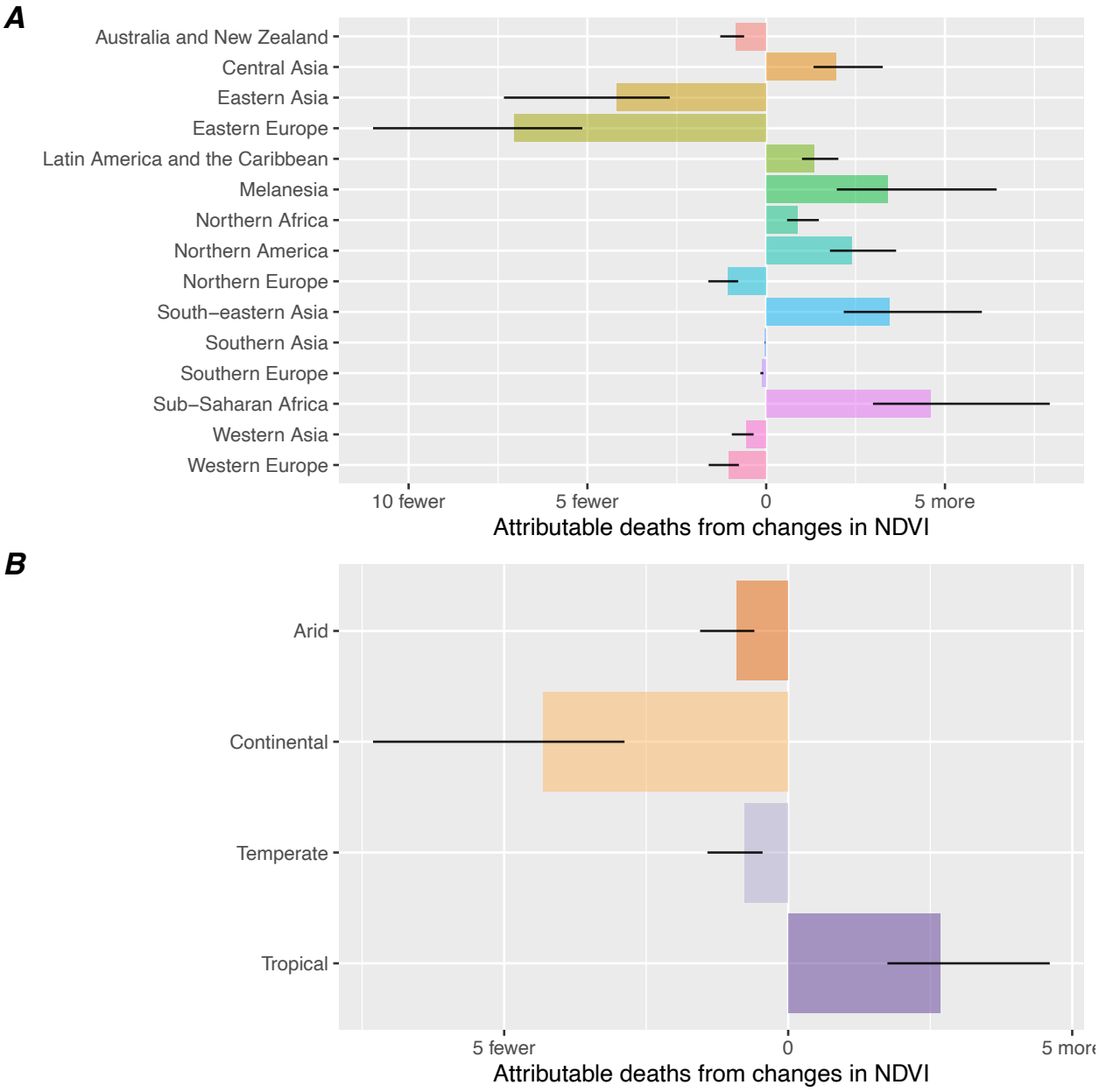

Figure S7. *Total associated changes in deaths per 100,000 from changes in average population-weighted peak season Normalized Difference Vegetation Index from 2014-2018 to 2019-2023 to the 2020 population, by region (panel A) and climate classification (panel B). One city classified as "Polar" was dropped from panel B (El Alto, Bolivia, 4.78 (95% CI: 3.11, 8.51) more deaths per 100,000 population). The black bars represent the 95% confidence intervals, considering measured error in the mortality and risk ratio estimates.*

Table S2. *Total change in deaths in absolute and population-standardized terms from changes in in average population-weighted peak season Normalized Difference Vegetation Index from 2014-2018 to 2019-2023 in the 2020 population, by region.*

Region	Population (2020)	Change in mortality	95% CI absolute		Change in mortality (per 100,000)	95% CI (per 100,000)	
			lb	ub		lb	ub
Australia and New Zealand	12345979	-103	-159	-76	-0.84	-1.28	-0.62
Central Asia	12976956	253	172	423	1.95	1.32	3.26
Eastern Asia	492132074	-20593	-36095	-13269	-4.18	-7.33	-2.70
Eastern Europe	64369399	-4540	-7078	-3311	-7.05	-11.00	-5.14
Latin America and the Caribbean	229040750	3066	2294	4623	1.34	1.00	2.02
Melanesia	652835	22	13	42	3.39	1.98	6.45
Northern Africa	78336973	690	458	1152	0.88	0.58	1.47
Northern America	140358784	3362	2503	5100	2.40	1.78	3.63
Northern Europe	28851881	-305	-467	-226	-1.06	-1.62	-0.78
South-eastern Asia	202014534	6951	4383	12186	3.44	2.17	6.03
Southern Asia	467009884	-194	-209	-131	-0.04	-0.04	-0.03
Southern Europe	38150645	-41	-62	-30	-0.11	-0.16	-0.08
Sub-Saharan Africa	199295623	9135	5953	15806	4.58	2.99	7.93
Western Asia	111143374	-606	-1069	-392	-0.55	-0.96	-0.35
Western Europe	41372890	-430	-665	-315	-1.04	-1.61	-0.76

Table S3. *Total change in deaths in absolute and population-standardized terms from changes in in average population-weighted peak season Normalized Difference Vegetation Index from 2014-2018 to 2019-2023 in the 2020 population, by climate classification.*

Climate Classification	Population (2020)	Change in mortality	95% CI absolute		Change in mortality (per 100,000)	95% CI (per 100,000)	
			lb	ub		lb	ub
Arid	437077498	-3942	-6777	-2604	-0.90	-1.55	-0.60
Continental	253600401	-10919	-18535	-7307	-4.31	-7.31	-2.88
Polar	1885470	90	59	160	4.78	3.11	8.51
Temperate	778051544	-5907	-11055	-3509	-0.76	-1.42	-0.45
Tropical	647437668	17345	11309	29813	2.68	1.75	4.60